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Parameter uncertainty analysis for an EMIC and a terrestrial vegetation model

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For quantitative discussions on the reliability of the modeled future climate, the sensitivity of the model's outputs to possible perturbations is needed to be examined carefully. However, as it is not realistic for state-of-art GCMs to carry out long ensemble runs for a large number of members, a reasonable substitution for such analyses will be to use Earth system models of intermediate complexity (EMICs). MIROC-lite, an EMIC used in this study, was originally developed in 2001 based on MIROC (an GCM) and is consists of an ocean GCM and a 2D energy moisture balance model for atmosphere. Using this model, we carried out an ensemble experiment perturbing 14 parameters (suggested by the model developer) at once with 300 members for which parameter sets were generated by the Latin hypercube for all parameters to have flat distributions in the predetermined ranges. After 3,000 year run to obtain quasi-equilibrium states, the average of air temperature, specific humidity, ocean temperature and ocean salinity in the last 100 years was compared to NCEP/NCAR reanalysis or World Ocean Atlas observation data. Consequently, it was found that among the parameters perturbed heat diffusivity plays the most significant role in deciding the pattern of the variables examined in this analysis, while the amount of the freshwater flux adjustment plays a comparable role for ocean salinity.

In the same manner, to investigate the uncertainty in terrestrial vegetation models, multi-parameter ensemble experiments perturbing nine parameters, suggested by the model developer, which control photosynthesis and soil decomposition were conducted for two models; Sim-CYCLE (Simulation model of Carbon Cycle in Land Ecosystems) and its successor VISIT (Vegetation Integrative Simulator for Trace gasses). In this experiment having 300 members, again generated by Latin hypercube, as the perturbation coefficients of 0.5-1.5 were multiplied to the default values, and it was revealed that a larger parameter-caused difference was made in the spin-up stage, while a significant disperse was observed also in the transient period representing the years 1901-2100. The most significant effects to the total ecosystem carbon storage during the spin-up were given by specific leaf area and one of the soil decomposition parameters, while in the transient period light use efficiency and maximum photosynthesis rate were the most influential to the carbon storage.

After examining the parameter uncertainty in each of above two kinds of models, we are now trying to loosely couple the two models, in order to consider the carbon cycle feedback to global warming. In the system, after spinning up two models, first MIROC-lite runs a year to take the temperature rise for a given CO2 concentration change, and then using global mean surface air temperature as the key variable, climatic condition data files, to drive Sim-CYCLE, of the most suitable year are extracted from the output archive of a preperformed GCM run with 1% per year CO2 increase for 150 years. Next is the Sim-CYCLE's turn to run for a year to calculate the change in the total ecosystem carbon storage for evaluating the feedback of the terrestrial carbon cycle. The system is closed when a new CO2 concentration, after considering the flux from the terrestrial ecosystem, is input to run MIROC-lite for the next one year. The cycle is iterated for 100 years or more. At the presentation, results from an ensemble experiment will be reported.